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ABSTRACT

This paper examines general systems theory as it applies to higher education institutions. Using this approach, the university is viewed as a system (comprised of subsystems) that interacts with the external environment. The first sections of the paper review general systems theory and its application to management, and examine some theoretical applications that can be adapted to higher education institutions. The paper then presents a hypothetical model of a technology subsystem, with faculty, support staff, student services, and libraries as the other subsystems. Central administration is shown as a subsystem to manage and control other systems. The interactions of these subsystems influence the outputs of the university by adding distance education, interactive video conferencing, and computer literate graduates to more traditional outputs. (Contains 19 references.) (CH)

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# The Systems Approach to the University: Integrating Technology

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## Abstract

Increased use of computer-based technology has made a profound impact on universities in the areas of administration, teaching, and research. Administrators, faculty, staff, and students are all effected when technology is integrated into the university. This paper illustrates an application of general systems theory viewing the university as a system, comprised of subsystems, which interacts with the external environment. The systems approach requires new ways of thinking and problem-solving by considering an action taken by one of the subsystems as having an impact on other subsystems. With the addition of technology as a subsystem, new interactions are developed and subsystems are influenced in new ways. A model is presented using a technology subsystem, with faculty, support staff, student services, and libraries as the other subsystems. Central administration is shown as a subsystem to manage and control other subsystems. The interactions of these subsystems influence the outputs of the university by adding distance education, interactive video conferences, and computer literate graduates to the more traditional outputs.

**General Systems Theory and the University**

In a system the whole is greater than the sum of its parts. This statement is based on synergy that can be equated to 2 + 2 is more than 4. The interrelationship of the parts work to support and add to the workings of other parts. To examine the human body as an example, the body is composed of several systems, e.g., circulatory system, nervous system, respiratory system, and the others, that make up the body to enable it to function efficiently. The body can be considered as a system comprised of subsystems and interacting with the environment. When one subsystem is not functioning properly, the other subsystems are affected and this causes the body to lose some effectiveness. The same applies to an organization that is comprised of many systems that must function efficiently for the organization to be effective.

Technology has applications both with the human system and organizational systems. The difference is that for human systems the technology remains external and with organizations technology can be incorporated as a subsystem. External technology permits health care professionals to better diagnose and treat malfunctions of the subsystems of the human body. When a technology subsystem is added and incorporated into the organization, technology becomes another subsystem of the organization. The organization has greater capability than before and is more effective in accomplishing its goals and objectives. This paper examines the General Systems Theory (GST) and how it can be applied to institutions of higher education. A model is presented that shows the addition of a technology subsystem and how it interacts with and influences other subsystems of a university. Also conclusions about the theory and its application are developed.

## General Systems Theory

General Systems Theory has evolved over time. Its roots can be traced back to ancient philosophers, but it was not until shortly before World War II with the writings of Ludwig von Bertalanffy, an Austrian biologist, that some of the ideas were developed. In its broadest sense, it has become a collection of principles, tools, problems, methods and techniques associated with systems. It considers the arrangement of certain components, interrelated to form a whole, with the whole being greater than the sum of the parts. A formal definition expresses a system as "a set of objects together with relationships between objects and between their attributes"[1] (Hall and Fagan, 1956, p. 18).

The concepts of GST were first applied to biology by von Bertalanffy as an attempt to overcome specialization and to consider a system with its interacting parts not only as a separate whole, but also interacting with its external environment. This has led to systems science, cybernetics, automation, and systems engineering. Outgrowths of the GST led to the development of information theory by Shannon and Weaver in 1949 and game theory by Van Newmann and Morgenstern in 1947 (von Bertalanffy, 1968).

In 1954, the Society for the Advancement of General Systems Research originated from a discussion between von Bertalanffy (biologist), Anatol Rapaport (applied mathematician & philosopher), Ralph Gerard (physiologist) and Kenneth Boulding (economist). This same year, the American Association for the Advancement of Science published the manifesto for the

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[1]A. D. Hall and R. E. Fagen developed a formal definition of a system. The definition was later quoted by R. W. Backoff and B. M. Mitnick in 1981 who did not attempt to modify it.

society[2] and defined GST as any theoretical system of interest to more than one discipline (Boulding, 1972). From these beginnings, GST has been applied in the physical sciences and the social sciences. Various models for a systems approach have evolved from the basic concepts. One model developed by Schoderbek, Schoderbek, and Kefalas (1990) shows the overall systems approach with the main elements GST and particularized systems approaches including operations research, systems analysis, cybernetics, and systems engineering.

The systems approach is a departure from traditional approaches and requires new ways of thinking and problem-solving. It supplements rather than replaces the analytical approach and focuses on the processes that link parts together. Systems science recognizes that science and the humanities cannot be separated. Humanities identify problems to be solved and science solves them (Schoderbek, Schoderbek and Kefalas, 1990).

Churchman's (1968) view of the systems approach and systems thinking has the following basic considerations:

1. The total system has objectives and performance measures,
2. The system's environment must be considered,
3. The resources of the system must be determined,
4. The components of the system must be defined, and

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[2]The original purpose and functions of the Society for General Systems Research are stated by von Bertalanffy (1968).

> The Society of General Systems Research was organized in 1954 to further the development of theoretical systems which are applicable to more than one of the traditional departments of knowledge. Major functions are to: (1) investigate the isomorphy of concepts, laws, and models of various fields, and to help in the useful transfers from one field to another; (2) encourage the development of adequate theoretical models in fields which lack them, (3) minimize the duplication of theoretical effort in different fields; (4) promote the unity of science through improving communication among specialists. (p. 15).

Also see von Bertalanffy (1972).



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5. The management of the system must be set.[3]

Interest in general systems theory seems to have peaked in the early 1970s. When interest was high, Clark (1972) proposed a joint council on General Systems Education, which was to include a national coordinating agency and a network of centers for general systems education. The article suggested several degree programs in general systems education. Since then, the systems approach has continued as a relatively specialized subject in some disciplines, in particular business administration and management.[4]

**General Systems Theory and Management**

Concepts, principles of systems, and a highly structured means of analyzing systems have been developed in the management discipline. GST found a place in management where the different elements of an organization are viewed as subsystems of the organization interacting with each other, and the external environment. One such view is shown (Figure 1). Four of the five basic considerations listed by Churchman are readily apparent in this model. Objectives and performance measures are not part of the general model (Figure 1), but their importance cannot be overlooked. Goals and their evaluation are what keeps the system alive, and give meaning to its existence. When the strategic plan is implemented, milestones are reached with measurements taken to determine if the established goals have been reached.

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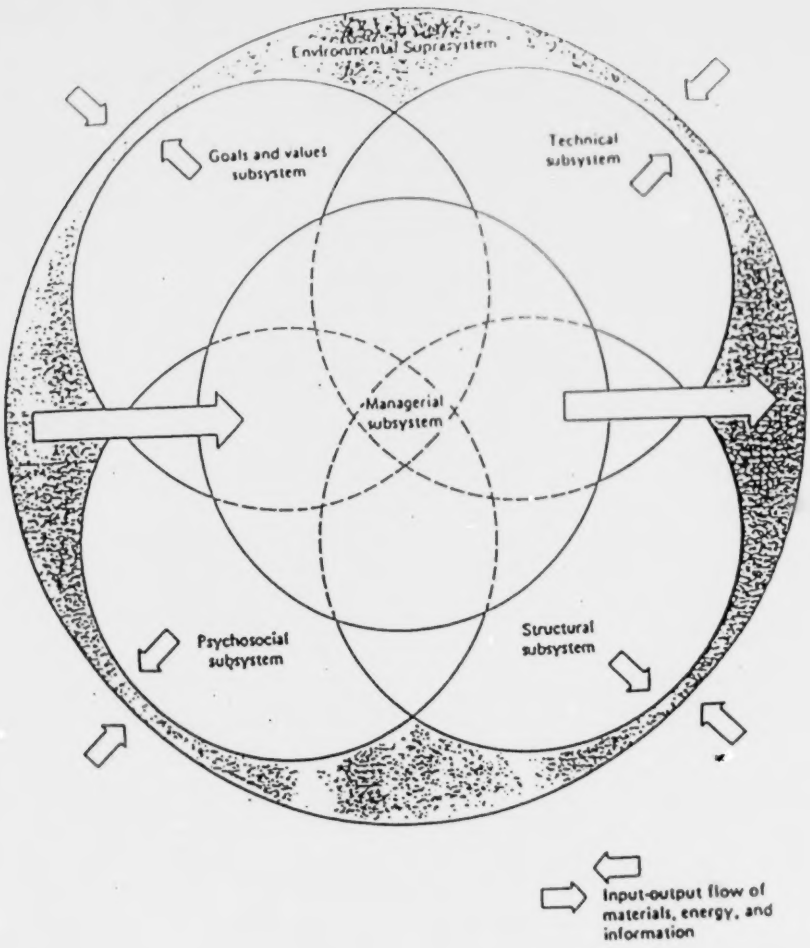
[3]For a discussion of these points see C. W. Churchman (1968), Ch. 3 and P. P. Schoderbek, C. G. Schoderbek and A. G. Kefalas, (1990), Ch. 1.

[4]Neither management nor education literature shows the reasons for this decline. It can be speculated that the systems approach was adapted as a panacea for all previous ills before applications of the concept were well thought out. Possibly when general systems theory was not all things to all people it fell into disfavor. Especially in management particularized systems are more in favor than general systems.

Figure 1 - The Organization System




Source: Kast and Rosenzweig (1985), p. 17.

In management science, systems are classified by their complexity on a continuum from simple to the highly complex depending on the number of parts, and the interaction between each individual part and every other part. A second classification is either deterministic or probabilistic based on the ability to measure the influence one part has on another. A deterministic system is one in which the parts interact in an absolutely known manner. The



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probabilistic system is one in which it is not known precisely how the components will interact. Managers deal with systems which are both complex and probabilistic (Flippo and Munsinger, 1982).

When the organization is conscientiously recognized as a system, the complexity of managing the organization can be realized. Potential benefits of systems thinking to managers within the organization are:

> 1. The manager ceases to work from a narrow functional viewpoint and identifies other subsystems which are inputs or outputs to the system.
>
> 2. The manager views his goals as being related to the larger goals set by the organization.
>
> 3. The organization is able to structure the subsystems so they will be consistent with the systems goals.
>
> 4. The systems approach with its goals attainment model permits evaluation of the effectiveness of the organization and the subsystems. (Schoderbek, Schoderbek and Kefalas, 1990, pp. 63, 64)

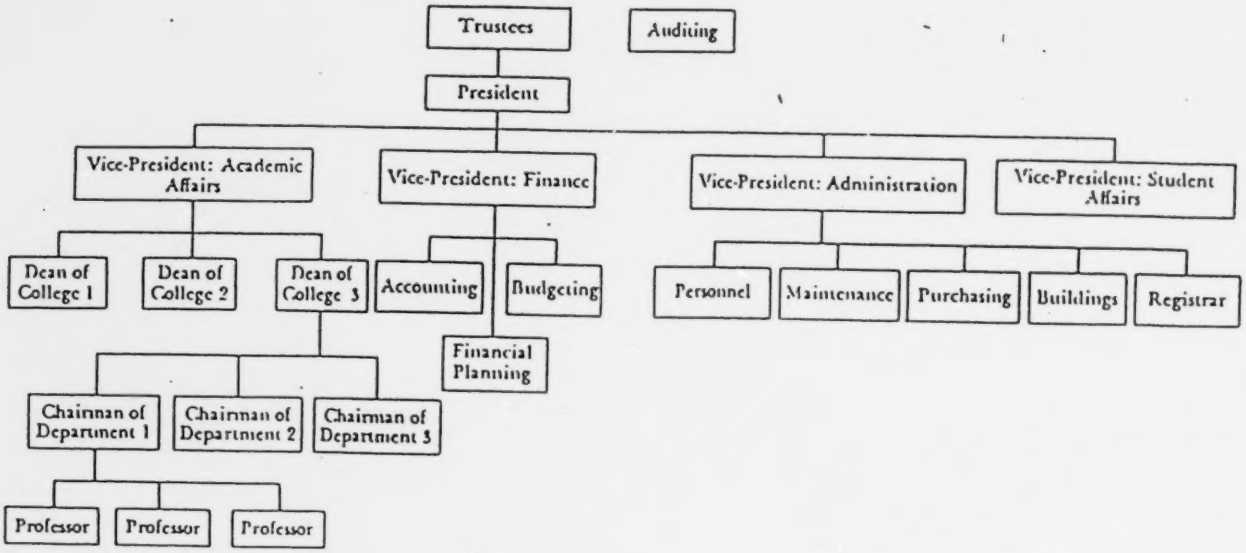
These points apply to any organization including an institution of higher education. The organization must be recognized as a system and be managed like a system. Only then will the expected benefits will accrue.

**Theoretical Application of General Systems Theory**

The systems approach can be adapted to a university. The university is both complex and probabilistic. Systems theory classifies the university as a system with the various academic entities (colleges) and non-academic departments as subsystems. Each of these units will have subsystems of their own. Richman and Farmer (1974) showed a formal organizational chart of the university (Figure 2) with functional arrangements but does not show the interaction of the subelements. This is in sharp contrast with the systems view which

considers the functional elements to be subsystems interacting with each other in a common environment and allows for the interactions both of the subsystems and their external environments.

Figure 2 - Formal University Authority Relationships




Source: Richman and Farmer (1974) p. 196.

The different administrative elements are systems within the larger system of the university. Using the organizational view of a system, which was shown in Figure 2, with inputs, processes and outputs, it is possible to view the university as having interrelated systems interacting with other internal and external systems. This permits analyzing the university using system analysis models from the management discipline.[5] One conceptual model of the university is shown in Figure 3.

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[5]F. E. Kast and J. E. Rosenzweig (1985), Ch. 21 provide an analysis of universities in this framework.



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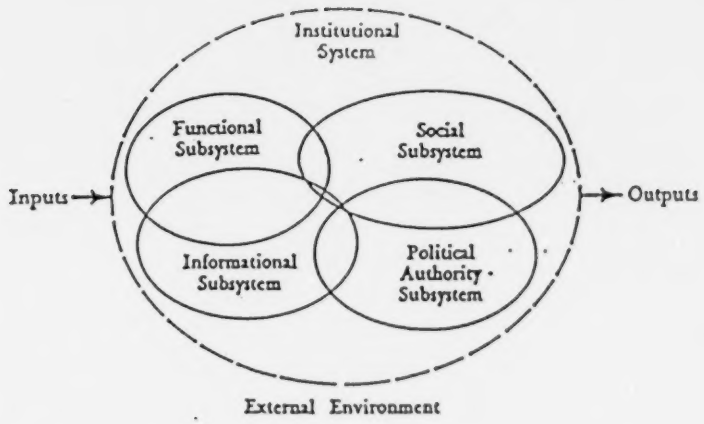
Figure 3 - An Open System




Source: Richman and Farmer (1974) p. 73.

A rather marked difference in this model and the one shown in Figure 1 is that the managerial subsystem is not superimposed on the other subsystems. Richman and Farmer's model above does not show the university having a subsystem for managing or governing the institution. Millet (1968) developed a systems analysis model of a university that considers input, process, and output. This model does not show interactions of subsystems in a university or how the university is managed.

Merson and Qualls (1979) identified six major systems which needed improvement in institutions of higher education. They did not address the systems concept, but by identifying the systems, some aspects of systems thinking are apparent. Two of the systems listed are 1) planning and resource allocation and 2) developing an organizational philosophy. The latter is a basis for establishing goals that can be quantified. These measurable goals can be used for

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planning and resource allocation. Evaluation of the planning and resource allocation can be accomplished using one of the systems analysis models.[6]

Critics of the systems approach are numerous. One of the major shortcomings pointed out by Matthies (1970) is that many organizations do not have or use a systems analyst who would view the university not as a series of departments, but channels of action. Hoos (1972) pointed out shortcomings of the systems approach in several fields, including education, but does not offer alternatives. Hoos may have been searching for perfection in a man-made system and was not willing to examine the system to determine which elements can be useful in any of the fields which were criticized.[7] With systems, as with anything else, it is often easy to find fault, but difficult to suggest a better alternative.

**The Systems Approach and the University**

In either a university or business, a mission is necessary to define why the institution or organization exists. Once this is established, goals are necessary to give direction. As compared to business, which can develop qualitative and quantifiable goals, the goals established in a university are not as easily measured. Millet (1968) advocates systems analysis as a means to develop a clearer understanding of university operations. Systems analysis can be used as a method of determining the progress a university is making to achieve its goals. He stated "The American university today can ill afford to do without systems analysis and a planning-programming budget system." (p. 106). Often in a university, there are differences in the

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[6]E. B. Flippo and G. M. Munsinger (1982) Chs. 21 through 24 examine various models in detail. D. I. Cleland and W. R. King (1985) Ch. 7 examine budgeting methods used in systems analysis.

[7] Hoos later had a bit of a different view. R. Lilienfeld (1978) quotes Hoos "...the systems approach is a kind of a mosaic made up of bits and pieces of ideas, theories and methodology from a number of disciplines discernible among which are - in addition to engineering - sociology, biology, philosophy, psychology and economics." (p. 233).

established goals and those pursued. Richman & Farmer (1974) cite several studies that found goals often pursued are a combination of what is and what should be. Budgets often determine actual goals by limiting what can be accomplished.

An additional constraint is that constituents often are able to impose political, legal, or economic power to further their wishes. Hall (1981) points out that professors with tenure may be more committed to their disciplines than to the institution and may provide an entirely different set (or sets) of goals. The sometimes conflicting goals of the external and internal constituents force the administrator to arrive at a consensus which will give the university a sense of direction in keeping with the mission of the university. Institutional goals must satisfy both internal and external constituents, or the institution will lack direction. The administrator who comes from the faculty and expects to return to the faculty often lacks training in leadership and management skills because in his past role these were neither acquired nor practiced. Richman and Farmer (1974) have pointed out this problem, but do not suggest solutions.

Westmeyer (1990) recognizes the university as an open social system which can be infiltrated from the outside. In the case of a state university, he cites examples of outside influences; the legislature, coordinating boards, and boards of regents. Other outside influences (e.g., accrediting agencies) can exert a powerful influence.

Richman and Farmer (1974) give an example of a small liberal arts college that established seven basic goals. This college knows what it wants to do and what it should do with limited resources. It used these resources effectively and efficiently and in ways that can be observed, evaluated, and verified. Other administrators can benefit from this example by establishing well-defined goals and accumulating information to determine if goals are being

met. The result is effective, efficient management of the university. The managerial subsystem shown in Figure 1 will fulfill its central role in goal setting and meet its requirements to plan, to design organizations, and to control activities.

McCorkle and Archibald (1982) do not directly address the systems approach. They propose definite multiyear goals that are expected to be realized in a rolling two to three year time period. These multiyear goals are measurable and can be evaluated. They also emphasize the way the concepts and processes are applied to any one institution will depend on the unique character of that institution. This concept is similar to systems thinking and may have been influenced by it.

**University Management using the Systems Approach**

The first requirement in applying systems thinking to a university is for administrators to adopt a new way of thinking. The administrator would think from a systems approach, and would consider how inputs from the external environment would influence internal subsystems. Outputs of the system, the university, to the external environment would also be considered. For example, the creation, change, or elimination of a program has repercussions not only for professors who teach that program, but also on support personnel, support facilities, students, and university finances. When all of the above are considered as subsystems, the big picture of the overall impact on the university is much clearer. Second, systems thinking would cause various administrators to relate their goals to university goals. Rather than considering changes from a narrow, functional view, the overall institution becomes the focus.

Many administrators come from the faculty and expect to return to the faculty are not trained as administrators and few achieve a level of expertise in administration. The issue of

training faculty to be administrators is a subject worthy of further investigation. As today's society becomes more complex administrators who were able to "muddle through" in the past are now out of place.

Technology has made dramatic changes in society and has changed the paradigm of organizations. Technological advances prompt a new look at a university and its subsystems. To illustrate these changes in a university setting six subsystems are identified; faculty, support staff, student services, technology, libraries, and central administration. How technological advances in computers and communications impact all subsystems and their relationships with other subsystems of the university is examined. The technology subsystem also affects the outputs of the university by having computer literate graduates, and giving the university the ability to utilize the full range of distance education programming.

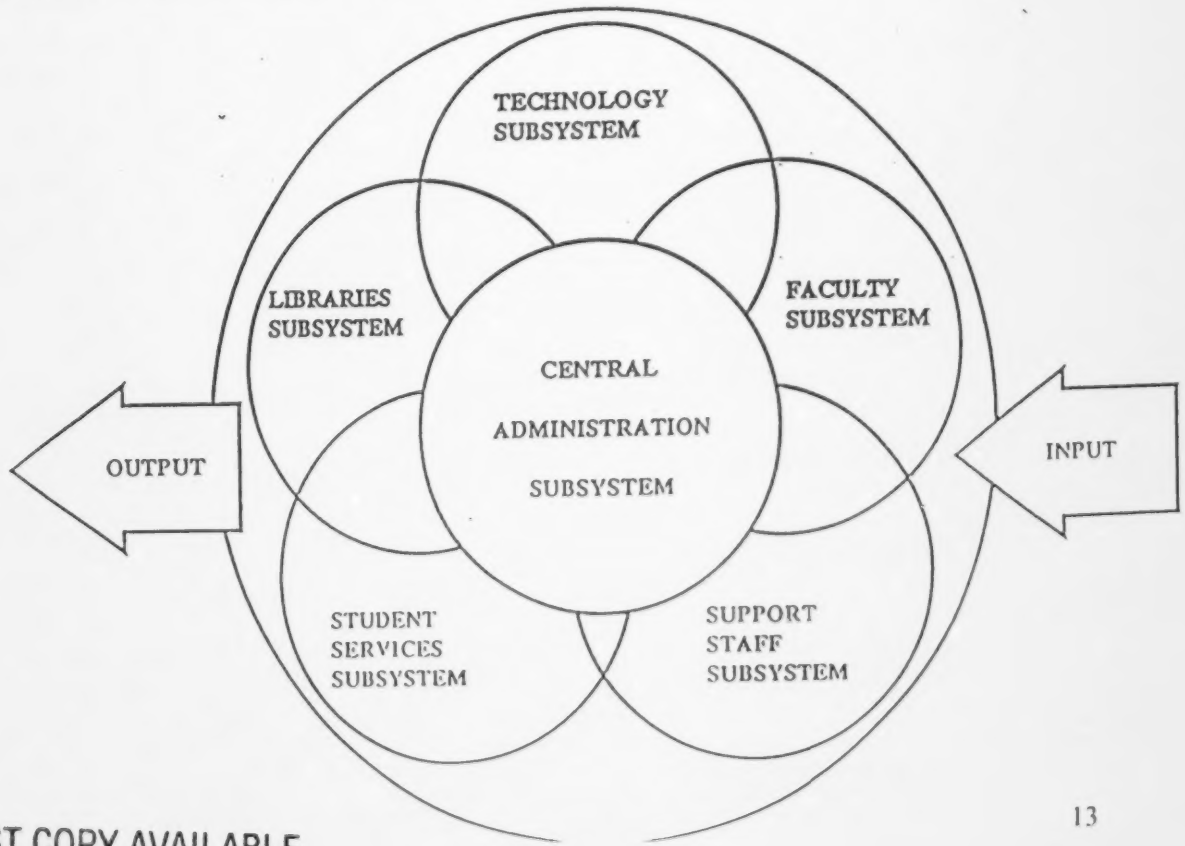
The faculty, in addition to their more traditional role, with the introduction of technology now can use computer enhanced instruction in the classroom, provide distance education classes, present courses by television (both on and off campus), conduct interactive video conferences, use electronic mail interchanges with students and other researchers in their field, and use more powerful computers for solving mathematical models.

The support staff now routinely uses computers for record keeping in many areas such as personnel, maintenance, purchasing, and building and grounds. The student services subsystem is an expanded concept of student services including all areas affecting students, including admissions, registration, student accounts and grades, financial aid, housing, student organizations, graduation, and placement follow-up services.

The library subsystem uses technology to automate many functions including library access, checking books in and out, online catalogues, data searching using CD-ROMS and online connections, and obtaining interlibrary loan material. Central administration integrates the other subsystems. It gives direction by determining the university's mission, establishing long-range goals, and plans to meet these goals. Control is exercised by reviewing the shorter range goals and plans of other organization elements to ensure these are appropriate to support the long-range goals and plans of the university. Central administration also formulates the budget for the institution and uses the budget as the ultimate control tool to evaluate and control the other elements.

These subsystems are depicted in the model shown in the figure below.

Figure 4 - Model of the Systems View of a University



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This model can be used by an institution as a basis to establish a way of thinking that considers the interaction of the subsystems of the university. This way of thinking can enhance goal setting and planning processes and give new insights into the budgeting process.

To illustrate the interaction of these subsystems in a university, a hypothetical situation is developed. After informal discussion with local business and community leaders, faculty determined a need for graduates with a masters degree in a field not being currently offered. Faculty determined the new program will "fit" after an examination of the university's current long range goals, objectives, and plans. Central administration is approached and gives the approval for a preliminary study. Faculty could be given the responsibility of coordinating inputs from the other subsystems and then presenting central administration with a complete package.

Faculty would prepare a tentative curriculum as a starting point. Once this is accomplished, the next step is to make a preliminary cost analysis. Faculty costs would be determined by deciding if current faculty are available to teach the course or if additional faculty are required. Other subsystems must be included. Technology to deliver the program would be costed based on the need for integrating technology in offices, classrooms, and laboratories with the necessary hardware and software. In the support staff areas, it is necessary to determine the availability of offices, classrooms, and laboratories in the current physical plant (or the cost of new or renovated facilities) plus the salaries of any additional support staff required. Libraries would be consulted about physical space as well as books, journals, and other materials required by the new program. Student services considers increased workload (if any) and determine if there is a requirement for additional staffing or facilities.

Preliminary costs would be compared to additional revenue expected from increased enrollments in the university and other expected sources of funding. (It is possible that the program might draw from the current student body with no additional enrollments. Should this be the case the impact on other programs losing enrollments must be considered.) In determination of expected costs and revenues the interaction of faculty and the other subsystems is a must!

The completed (tentative) package is now ready for presentation to central administration where the package can be accepted, returned to faculty for modification, or rejected. The last of these probably would not happen if central administration had been informed early in the process and been advised of the progress and any problems as they developed. If the program meets the screening criteria of central administration and is accepted (or accepted with modifications), central administration would direct the revision of midrange and short range goals, objectives, and plans. Central administration would be responsible for directing the implementation of the new program and make necessary budget adjustments.

## Summary and Conclusions

The hypothetical situation presented and the literature cited in the paper clearly show that the systems view and the new way of thinking required by the systems view can be extremely beneficial to a university. It is possible that some educators reading this example may state something to the effect that is the way we do (or should do) things at our university. If this is the case, they are showing that the concept of systems theory is understood and in some cases practiced.

In today's world with concerns about funding of universities, increasing technological advances, changing demographics of student bodies, and more cries from various sources for accountability the universities that take a proactive approach to the educational climate are the one that have the greater opportunities to continue in traditional roles as institutions of higher education.

Specific examples of where and how the systems approach have been used in higher education institutions is lacking in the literature. Because of this, it is not possible to determine how effective or efficient the systems approach has been. Literature infers that some elements of the systems approach may have been implemented. Higher education can reap the benefits from the applied aspects and make adaptations of GST to fit the educational environment. The application of GST to higher education can benefit institutions in several areas. The benefits accrue when the institution establishes measurable goals, develops methods to determine how well these goals are being met, provides development programs for new administrators who come from the faculty, and create a culture leading to systems thinking.

Realistic, quantifiable goals can be used to budget and evaluate performance. This is especially important because of the prospects of decreased funding for public institutions. A continuing call for accountability in higher education is also being heard, so evaluation is becoming more important.

The model presented in this paper using the systems approach can be examined by administrators and applied in higher education. This model shows how technology has impact on many functional areas of an institution and leads to insights about how other applications of technology can be investigated by an institution. When disciplines in higher education break

from the narrow functional mold and use the new way of thinking the results will be beneficial and tangible.

A word of caution: to blindly accept any concept, including general systems theory, as "the best thing since sliced bread" without exploring its implications can result in disaster. Unfortunately, the systems concept in its present state remains hidden in functional textbooks and obscure jargon of the discipline. Only when new ways of thinking are adapted and practiced will the full potential of systems theory be realized.

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